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ADVANCED REFRACTORY ALLOY CORROSION LOOP PROGRAM

Quarterly Progress Report No. 1
For Quarter Ending July 15, 1965

By
R. W. HARRISON
and
E. E. HOFFMAN

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MISSILE AND SPACE DIVISION
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ADVANCED REFRACTORY ALLOY CORROSION LOOP PROGRAM

QUARTERLY PROGRESS REPORT 1

Covering the Period
April 15, 1965 to July 15, 1965

Edited by
R. W. Harrison
Project Metallurgist

Approved by
E. E. Hoffman
Manager, Corrosion Technology

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewis Research Center

Under Contract NAS 3-6474

July 21, 1965

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FOREWORD

The work described herein is sponsored by the National Aeronautics and Space Administration under Contract NAS 3-6474. For this program, Mr. R. L. Davies is the NASA Project Manager.

The program is being administered for the General Electric Company by Dr. J. W. Semmel, Jr., and E. E. Hoffman is acting as the Program Manager. J. Holowach, the Project Engineer, is responsible for the loop design, facilities procurement, and test operations. R. W. Harrison, the Project Metallurgist, is responsible for the materials procurement, utilization, and evaluation aspects of the program. Personnel making major contributions to the program during the current reporting period include:

Alkali Metal Purification and Handling - Dr. R. B. Hand, L. E. Dotson, and J. R. Reeves.

Refractory Alloy Procurement - R. G. Frank.

Quality Assurance and Reliability - G. L. Hilbrich.

TABLES

CONTENTS

ADVANCED REFRACTORY ALLOY CORROSION LOOP PROGRAM

I INTRODUCTION

This report covers the period, from April 15, 1965 to July 15, 1965, of a program to fabricate, operate for 10,000 hours, and evaluate a potassium corrosion test loop constructed of T-222, T-111, FS-85, or D-43 alloy. Candidate materials for evaluation in the turbine simulator include Mo-TZC and Cb-132M. The loop design will be similar to the Prototype Loop, a two-phase, forced convection, potassium corrosion test loop, which is being developed under Contract NAS 3-2547. Lithium will be heated by direct resistance in a primary loop. Heat rejection for condensation in the secondary loop will be accomplished by radiation in a high vacuum environment. The compatibility of the selected materials will be evaluated at conditions representative of space electric power system operating conditions, namely:

a.	Boiling temperature	-	2050°F
b.	Superheat temperature	-	2150°F
c.	Condensing temperature	-	1400°F
d.	Subcooling temperature	-	1000°F
e.	Mass flow rate	-	40 lb/hr
f.	Boiler exit vapor velocity	-	50 ft/sec
g.	Average heat flux in boiler		
	Plug (0 to 18 inches)	-	250,000 BTU/hr ft^2
	Helix (18 to 250 inches)	-	5,000 BTU/hr ft^2

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II SUMMARY

During the first quarter of the program, work proceeded on the topics abstracted below:

Material vendors have been contacted, and the ordering of loop construction materials can commence promptly upon notification of the alloy selection by the NASA Project Manager.

A lithium shipping container has been designed and constructed. High purity lithium will be purchased from Lithium Corporation of America.

Mini-Flex Corporation, Lawndale, California, has demonstrated their capability to fabricate refractory alloy bellows, and an order for Cb-1Zr and T-111 bellows has been placed with this firm. Author

The proposed quality assurance plan and equipment log has been sent to the NASA Contracting Officer and Project Manager. Materials specifications have been prepared and submitted to the NASA Project Manager for approval.

III PROGRAM STATUS

A. Material Procurement

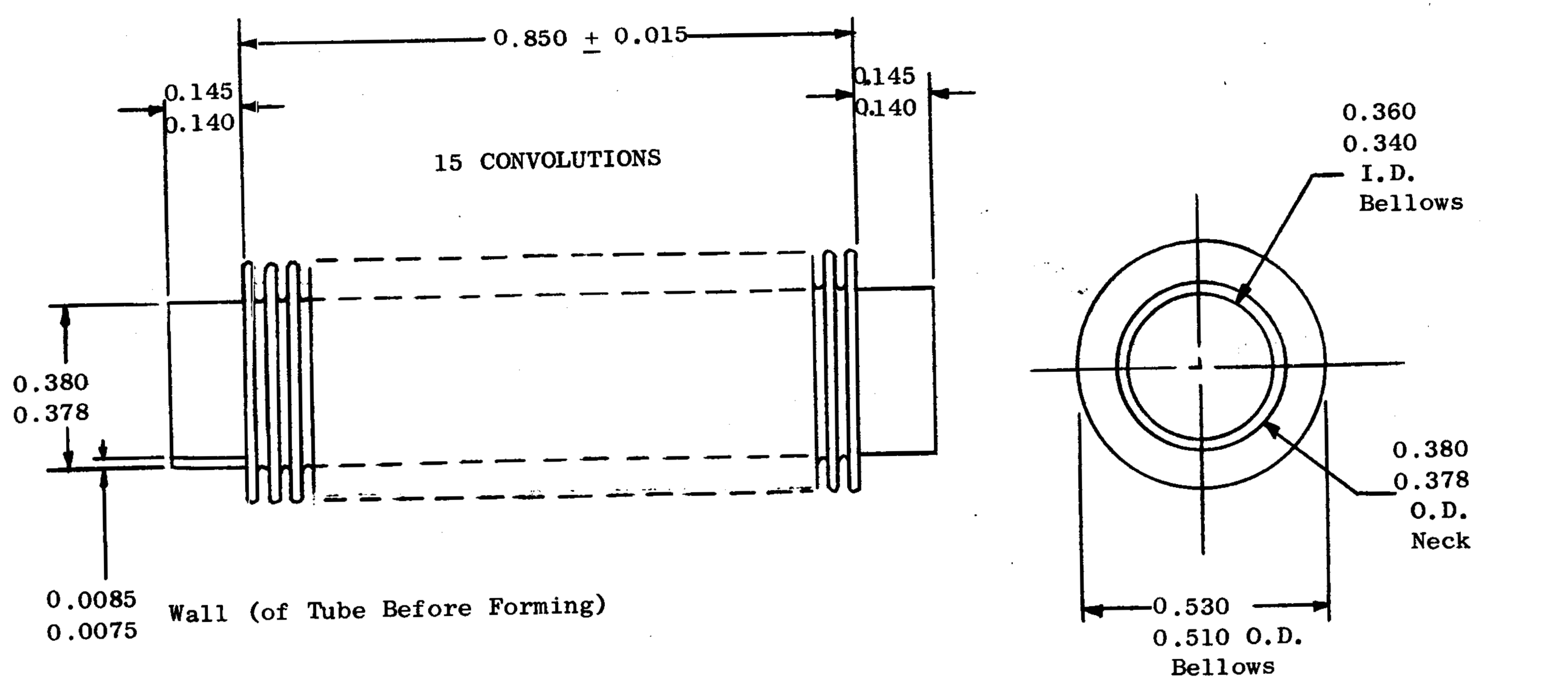
Vendor's quotations for the proposed containment alloys, T-222, T-111, FS-85 and D-43, are being evaluated, and ordering of material can commence promptly upon notification of the alloy selections by the NASA Project Manager.

The lithium shipping container was designed and constructed. Lithium vendors were contacted and their quotations were reviewed. High purity lithium will be purchased from the Lithium Corporation of America. Preliminary calculations have indicated the potassium distillation system for the Prototype Corrosion Test Loop will be adaptable to lithium purification with minor revisions.

Present plans are to use T-111 alloy bellows in the valves of the Advanced Refractory Alloy Corrosion Test Loop. Attempts by Standard-Thomson Corporation to produce T-111 alloy bellows by the procedures which were used previously to manufacture Cb-1Zr bellows for the Prototype Corrosion Test Loop were unsuccessful because of the combined greater strength of the T-111 alloy and the limited capacity of the forming equipment. Additional manufacturers were contacted and Mini-Flex Corporation, Lawndale, California, was the only other firm with successful refractory alloy experience that replied to the inquiry. (Although designed valve bellows contain 26 convolutions, bellows with 15 convolutions were ordered to initially evaluate the vendors' capabilities.) Two Cb-1Zr alloy bellows and two T-111 alloy bellows were fabricated successfully by Mini-Flex from the tube blanks supplied by General Electric. Metallographic examination of the cross section of the convolutions indicated excellent uniformity of wall thickness in these bellows. The axial deflection of the bellows as a function of load, determined by using a compression load cell in an Instron Tester, are presented in Table.I. While the spring rates of these bellows pose no difficulties for application in loop valves, the degree of permanent set bears consideration.

TABLE I. ROOM TEMPERATURE COMPRESSIVE PROPERTIES OF VALVE BELLOWS
0.520-INCH OD x 0.350-INCH ID WITH 15 CONVOLUTIONS IN A 0.850-INCH LENGTH

Alloy	Elastic Spring Rate lbs/Inch	Total Deflection at Yield Inch	Load at Yield lbs	Permanent Set In/In Deflection After Yield	Permanet Set In/Full 0.1 Inch Deflection
T-111	870	0.047	41	0.470	0.025
Cb-1Zr	314	0.070	22	0.900	0.027



While the spring rates of these bellows pose no difficulties for application in loop valves, the degree of permanent set bears consideration.

Permanent set begins as the bellows are deflected past the yield point. Each bellows was deflected 0.030 inch past the yield point producing 0.014 inch permanent set in the T-111 alloy bellows and 0.027 inch permanent set in the Cb-1Zr alloy bellows. For a full 0.10-inch deflection, the normal travel range of the metering valve, 0.025-inch permanet set would occur in the T-111 alloy bellows and 0.027-inch permanent set in the Cb-1Zr alloy bellows.

Although permanent set values for these two alloys appear similar, the extent of plastic deformation occurring after yield differs widely. In the Cb-1Zr alloy bellows, 90% of the deflection after yield results in permanent set as compared to only 47% in the T-111 alloy bellows. By increasing the number of bellows convolutions from 15 to 26, the amount of permanent set for a given amount of axial deflection will decrease. Bellows of this design have been ordered from Mini-Flex Corporation.

B. Quality Assurance

A proposed quality assurance plan and equipment log was prepared and sent to the NASA Contracting Officer and Project Manager. The procedures and specifications contained therein were prepared mainly for use on the Potassium Corrosion Test Loop Development Program, NAS 3-2547, and will be modified as experience gained on that program warrants.

To increase the expediency of inspection of incoming items, an inspection tag has been adopted. This form will replace the hold ticket, discrepancy report, and material identification tag which were used on the Potassium Corrosion Test Loop Development Program.

The materials specifications, Table II, have been submitted to the NASA Project Manager for approval:

TABLE II. MATERIALS SPECIFICATIONS

Number	Title
01-0010-00-A	Bar and Rod: (Cb-132M (Cb-20Ta-15W-5Mo-2Zr-0.13C) Alloy
01-0011-00-A	Bar and Rod: Mo-TZC (Mo-1.25Ti-0.15Zr-0.13C) Alloy
01-0013-00-B	Bar and Rod: D-43 (Cb-10W-1Zr-0.1C) Alloy
01-0014-00-C	Bar and Rod: T-222 (Ta-10.4W-2.4Hf-0.01C) Alloy
01-0015-00-B	Bar and Rod: T-111 (Ta-8W-2Hf) Alloy
01-0020-00-B	Sheet, Plate, and Strip: FS-85 (Cb-28Ta-10.5W-0.9Zr) Alloy
01-0021-00-B	Bar and Rod: FS-85 (Cb-28Ta-10.5W-0.9Zr) Alloy
01-0022-00-B	Seamless Tubing and Pipe: FS-85 (Cb-28Ta-10.5W-0.9Zr) Alloy
01-0035-00-B	Seamless Tubing and Pipe: T-111 (Ta-8W-2Hf) Alloy
01-0036-00-C	Seamless Tubing and Pipe: T-222 (Ta-10.4W-2.4Hf-0.01C) Alloy
01-0037-00-B	Seamless Tubing and Pipe: D-43 (Cb-10W-1Zr-0.1C) Alloy
01-0038-00-B	Sheet, Plate, and Strip: D-43 (Cb-10W-1Zr-0.1C Alloy
01-0039-00-B	Sheet, Plate, and Strip: T-222 (Ta-10.4W-2.4Hf-0.01C) Alloy
01-0040-00-B	Sheet, Plate, and Strip: T-111 (Ta-8W-2Hf) Alloy
01-0041-00-A	Foil: D-43 (Cb-10W-1Zr-0.1C) Alloy
01-0042-00-A	Foil: FS-85 (Cb-28Ta-10.5W-0.9Zr) Alloy
01-0043-00-A	Foil: T-111 (Ta-8W-2Hf) Alloy
01-0044-00-B	Foil: T-222 (Ta-10.4W-2.4Hf-0.01C) Alloy

Number	Title
01-0045-00-A	Wire: D-43 (Cb-10W-1Zr-0.1C) Alloy
01-0046-00-A	Wire: FS-85 (Cb-28Ta-10.5W-0.9Zr) Alloy
01-0047-00-B	Wire: T-222 (Ta-10.4W-2.4Hf-0.01C) Alloy
01-0048-00-A	Wire: T-111 (Ta-8W-2Hf) Alloy

VI FUTURE PLANS

Accomplishments in the next reporting period are contingent upon the forthcoming selection by the NASA Project Manager of the refractory alloy to be employed in loop construction.

High purity lithium will be ordered and received. Procurement of materials for construction of the lithium purification system will be initiated.

T-111 alloy and Cb-1Zr alloy bellows will be received and evaluated for incorporation in loop valves.

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